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MONTANA MILL RESIDUE ASSESSMENT AND SIMULATION SYSTEM

USER'S GUIDE

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MONTANA MILL RESIDUE ASSESSMENT AND SIMULATION SYSTEM

--USER'S GUIDE--

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Introduction

The *Montana Mill Residue Assessment and Simulation System* allows a user to estimate the volume of mill residue utilized and unutilized in Montana based on various assumptions related to supply, production, and use. The program's output is designed to indicate the volume of sawmill residue which is presently not committed to use by county or county group. Similar information regarding plywood residue is included for the state.

Section 1, "A Note on Mill Residue," defines mill residue and describes the source and use of mill residue in Montana. Section 2, "Preparing to Use the Program," provides instructions for installing and loading the program. Section 3, "Using the Program," introduces the important features of the program. The last section provides an interpretation of the "simulation results."

1. A Note on Mill Residue

1.1 Definition

Mill residue is a general term used to describe the portion of timber delivered to a processing plant that does not become part of the final primary product. For example, all wood fiber delivered to a sawmill that is not part of the lumber produced is referred to as "mill residue." The term residue is somewhat misleading because currently much, but not all, of the mill residue material is used to produce products or as fuel.

1.2 The Sources of Mill Residue

Although mill residue is produced by all plants processing timber into primary wood products, over 95 percent of the mill residue generated in Montana comes from sawmills and plywood plants. The three types of wood fiber residue generated at sawmills and plywood plants are:

(1) Coarse or chippable residue consisting of slabs, edgings, and trim from lumber manufacturing, log ends from sawmills and plywood plants, pieces of veneer unsuitable for plywood manufacture, and peeler cores from plywood plants not sawn into lumber;

(2) Fine residue consisting of sawdust or planer shavings from sawmills and sander dust from plywood plants; and

(3) Bark from sawmills and plywood plants.

The other components of mill residue in the forest products industry include peelings and log ends from the post and pole industry, log ends, peelings, and sometimes slabs from the house log industry and cull material from cedar products producers. The volumes involved are small, however, and are not included in this analysis.

1.3 The Use of Mill Residue

The major current and projected uses of mill residue in Montana include the following:

(1) The pulp and paper industry. This sector uses coarse residue and some fine residue (sawdust) as raw material to manufacture paper. Fine residue and bark are also used as fuel.

(2) Reconstituted board plants. These plants include a particleboard plant and a fiberboard plant. The particleboard plant primarily uses fine residue (planer shavings) as a raw material, while the fiberboard plant uses both fine residue and coarse residue.

(3) Energy facilities. Included here are facilities generating electricity and those using mill residue as fuel not included in the other categories. They use primarily bark and fine residues.

(4) Sawmills and plywood plants. These plants use a portion of the fine residue and bark they generate in their own operations to dry lumber or veneer or to provide winter heat.

(5) Other uses. There are several other uses of wood residue in the state, including decorative bark, garden mulch, residential fuel wood, and animal bedding. The volumes involved are small, however, and are not included in this analysis.

1.4 Units of Measure

Mill residue is expressed in thousands of cunits. A cunit is 100 cubic feet of solid wood and approximately 2,500 pounds oven dry weight. The energy equivalent of 1 cunit of residue is approximately 21 million BTUs.

2. Preparing to Use the Program

2.1 System Requirements

Hardware

- IBM PC, PC/XT, PC/AT or IBM-compatible personal computer.
- Two floppy-disk drives or one floppy- and one hard-disk drive.
- 320KB RAM.

Software

- PC- or MS-DOS 3.1 or higher.
- The Montana Mill Residue Assessment and Simulation System distribution diskettes 1 and 2.

2.2 Installing the Program

Hard-Disk Installation

It is suggested that a subdirectory be created to hold the files contained on the distribution diskettes. The following instructions assume that your hard-disk is identified as disk drive C.

(a) Create a subdirectory called MAS with the following commands (each command line is ended by pressing the "Enter" key on the keyboard):

```
C:
CD\
MD MAS
```

(b) Insert distribution diskette 1 into drive A. Load the files onto subdirectory MAS of the hard-disk by entering:

```
COPY A:*.* C:\MAS
```

(c) Insert distribution diskette 2 into drive A. Repeat the command in step (b) above.

Floppy-Disk Installation

No specific installation procedure is needed when using the program on a floppy-disk system.

3. Using the Program

3.1 Getting Started

On a Hard-Disk System

Make sure the C> prompt is on the screen. Enter the following commands to start the program (again, each command line is ended by pressing the "Enter" key on the keyboard):

```
C:
CD\MAS
MAS
```

On a Floppy-Disk System

Insert distribution diskette 1 into drive A and distribution diskette 2 into drive B. Make sure the A> prompt is on the screen. Enter the following commands to start the program:

```
A:
AMAS
```

3.2 Program Structure

The operation of the program is menu driven. A menu is, in essence, a list of possible tasks to be performed. Each item on a menu is designated by an alphanumeric label. The execution of any particular task is carried out by entering the appropriate label on the keyboard. Once the program is started, the following menu will appear on the monitor:

Figure 1
Main Menu

H. Help
I. Supply-Demand Assumptions
J. Mill Residue Generated
K. Supply-Demand Balance
L. Print Report
X. Exit

Menu item (H), *Help*, for example, provides on-line assistance for using the program. Menu item (X), *Exit*, on the other hand, instructs the program to quit running.

In some cases, the selection of a menu item may invoke a secondary menu, or submenu, if additional instructions from the user are required to complete the task. Upon completion of the submenu options, the program will always return to the previous menu from which the submenu is called. The menu-submenu hierarchy is illustrated in section 3.4. Similar structure is maintained consistently throughout the program.

3.3 Mill Residue Analysis

Menu item (I), *Supply-Demand Assumptions*, is the pivotal step in the analysis of mill residue. It allows a user to change the various assumptions related to mill residue supply and demand. The task of defining the assumptions is achieved through a submenu, which will be discussed in section 3.4. It should be noted that the program is initiated with a set of default assumptions, which will remain effective until changes are made via menu item (I). Any changes that are made will remain effective until instructions for revision are received from the user.

Based on the current set of supply-demand assumptions specified in menu item (I), mill residue supply and the supply-demand balance are determined and shown, respectively, in menu item (J), *Mill Residue Generated*, and (K), *Supply-Demand Balance*. Section 4 presents a detailed discussion of these two menu items.

Finally, menu item (L), *Print Report*, generates a report on the printer which summarizes the simulation results of menu items (J) and (K), as well as the underlying supply-demand assumptions of menu item (I).

While menu items (J), (K), and (L) suggest a logical sequence in deriving the simulation results, they need not be activated in that particular order. The selection of menu item (K) for the supply-demand balance, for example, is not conditional on the execution of menu item (J); the program will determine automatically all supply and demand information needed for completing this particular task. Similarly, a user can obtain the summary report via menu item (L) without first going through menu items (J) or (K).

3.4 Supply-Demand Assumptions

Upon selecting menu item (I), a user will be presented a submenu which consists of two panels: one lists assumptions related to mill residue supply, and the other lists assumptions related to mill residue demand (see figure 2).

Figure 2
Submenu: Supply-Demand Assumptions

Supply Assumptions

A. Lumber Production
B. Plywood Production
C. Residue Factors
D. Review Supply Assumptions

Demand Assumptions

E. Product Use
F. Hog Fuel Use
G. Review Demand Assumptions

X. Exit

Supply Assumptions

Mill residue generated is derived by applying residue factors to the volume of lumber and plywood production. Each one of these three determinants of mill residue generated (i.e., lumber production, plywood production, and residue factors) can be varied by the user via menu items (A), (B), and (C).

In menu item (A), *Lumber Production*, historic lumber production in Montana is available for counties or county groups defined as follows:

Beaverhead Area	- Beaverhead, Gallatin, Madison, Park
Broadwater Area	- Broadwater, Fergus, Jefferson, Judith Basin, Lewis & Clark, Meagher, Teton, Wheatland

Carbon Area	- Carbon, Musselshell, Powder River, Rosebud, Stillwater
Flathead County	- Flathead
Granite Area	- Granite, Powell, Ravalli
Lake Area	- Lake, Mineral, Sanders
Lincoln County	- Lincoln
Missoula County	- Missoula

If no other level of lumber production is specified, the program uses the most current 1986 data for the calculation of mill residue generated. Alternatively, a user can select a specific year's production figure displayed on the monitor or enter other estimates of lumber production.

In menu item (B), *Plywood Production*, historic plywood production data are available statewide. A user has the option of using the most current 1986 data (i.e., the default), specifying a specific year, or entering other estimates of plywood production.

The 1986 lumber and plywood production data used in the program are preliminary. The source for the revised lumber production data is the *Statistical Yearbook of the Western Lumber Industry*, Western Wood Products Association, Portland, Oregon. The updated plywood production data can be obtained from the American Plywood Association in Tacoma, Washington.

The program allows a user to enter actual lumber and plywood production through 1988. Nineteen eighty-seven and 1988 data can be entered permanently in the data base file named MAS.DBF using dBase III.

Residue factors are statewide averages by type, based on a survey of Montana's industry conducted by the University of Montana, Bureau of Business and Economic Research. They are displayed in menu item (C), *Residue Factors*, and can also be varied by the user. The default residue factors are shown in table 1. The residue factors show the volume of residue generated per thousand board feet (MBF), lumber tally, or per thousand square feet of plywood (MSF), 3/8 inch basis.

Table 1
Residue Factors

	Sawmill (Cunits/MBF)	Plywood (Cunits/MSF)
Coarse	0.53	0.28
Sawdust	0.23	
Sander dust		0.02
Planer shavings	0.21	
Bark	0.22	0.12
Total	1.19	**0.42**

Menu item (D), *Review Supply Assumptions*, provides a summary of the current set of assumptions that forms the basis for deriving mill residue supply.

Also included in the output, as a constant, are the estimated mill residue volumes available statewide from other producers.

Demand Assumptions

Mill residue can either be used as a raw material for wood and paper products, or as fuel in the form of hog fuel, both internally by the sawmills and plywood plants to dry products and produce winter heat, and externally by other facilities.

In menu item (E), *Product Use*, a user can specify various levels of product use to examine its effect on the mill residue supply-demand balance. The default demand for mill residue products is based on the indicated normal operating levels of the pulp and paper and reconstituted board plants using residue from Montana. Historic use of Montana mill residue by out-of-state plants is also included. The below normal level decreases total use of all residue types for products by 15 percent. The above-normal level increases total use by 15 percent. This increase would represent the consumption of an additional reconstituted board plant or a small pulp mill.

The rate of internal hog fuel use, which is directly related to lumber and plywood production, is determined within the program.

Menu item (F), *Hog Fuel Use*, allows a user to change the level of external hog fuel use by major purchasers of fine residue and bark used for fuel. Four levels are indicated: The default or normal level is based on the stated needs of the current purchasers of hog fuel from Montana mills. The below-normal level reduces this level by 150 thousand cunits annually. This is equivalent to what might happen if dramatic declines in natural gas and fuel oil prices took place. The above-normal level increases demand by 150 thousand cunits. This would supply a 25 to 30 megawatt power plant. The high level is 300 thousand cunits above the normal level. This is a volume sufficient to supply a 50 to 60 megawatt power plant.

Menu item (G), *Review Demand Assumptions*, provides a summary of the current set of assumptions that forms the basis for deriving the mill residue supply-demand balance.

By selecting menu item (X), *Exit*, the supply-demand assumptions submenu will be closed. It should be noted that, in a submenu, the exit command will simply instruct the program to return to the previous menu from which the submenu is called. The program will stop running only when the exit command in the main menu (see figure 1) is executed.

4. Simulation Result

Given the supply-demand assumptions discussed in section 3.4, the program automatically determines the volume of mill residue generated and the supply-demand balance in Montana, which can be viewed via menu items (J) and (K), respectively. The simulation results presented in the next two sections are based on the default assumptions related to mill residue supply and demand. They illustrate mill residue availability for 1986.

4.1 Mill Residue Generated

As noted earlier, part of the mill residue generated is used internally by the sawmills and plywood plants as hog fuel. The rate of internal hog fuel use varies directly with the rate of lumber and plywood production. Menu item (J) displays the supply of mill residue, both by type and by supply source, in two tables. Table 2 shows the volume of mill residue generated before internal fuel use. Table 3, on the other hand, shows the volume of mill residue that is available for product and external hog fuel use.

The assumption is that the mill would use its lowest value residue--bark and sander dust--for its internal use and try to market the remaining material. For sawmills, sawdust and planer shavings would be used, in that order, if the volume of bark generated is not sufficient to meet internal demand. (In reality, if no outlet exists for sawdust and planer shavings, a portion of these would be used as fuel internally, regardless of the bark volume available.)

Table 2
Mill Residue Generated before Internal Hog Fuel Use
Selected Montana Counties and County Groups, 1986
(In Thousands of Cunits)

	Coarse	Sawdust	Sander Dust	Planer Shavings	Bark	Total[2]
From lumber production[1]	828	359	0	328	343	1,859
Beaverhead Area	113	49	0	44	47	254
Broadwater Area	51	22	0	20	21	115
Carbon Area	3	1	0	1	1	7
Flathead County	166	72	0	65	69	373
Granite Area	97	42	0	38	40	218
Lake Area	103	44	0	40	42	232
Lincoln County	158	68	0	62	65	355
Missoula County	134	58	0	53	55	302
From plywood production[1]	187	0	13	0	80	281
Total[2]	1,016	359	13	328	424	2,141

[1] Statewide total production.

[2] Details for the rows and columns may not add to the total due to rounding in the computer program.

Table 3
Mill Residue Generated after Internal Hog Fuel Use
Selected Montana Counties and County Groups, 1986
(In Thousands of Cunits)

	Coarse	Sawdust	Sander Dust	Planer Shavings	Bark	Total[2]
From lumber production[1]	828	359	0	328	143	1,659
Beaverhead Area	113	49	0	44	19	227
Broadwater Area	51	22	0	20	8	103
Carbon Area	3	1	0	1	0	6
Flathead County	166	72	0	65	28	333
Granite Area	97	42	0	38	16	195
Lake Area	103	44	0	40	17	207
Lincoln County	158	68	0	62	27	317
Missoula County	134	58	0	53	23	269
From plywood production[1]	187	0	0	0	26	214
Total	1,016359		0	328	170	1,874

[1] Statewide total production.

[2] Details for the rows and columns may not add to the total due to rounding in the computer program.

The volumes of coarse residue, sawdust, planer shavings, and bark available from other sources are not reflected in the corresponding column totals of tables 1 and 2. The annual statewide estimates measured in thousands of cunits are: coarse 20; sawdust 10; planer shavings 10; and bark 20. Small quantities of this material are currently used; however, the majority remains unused.

4.2 Supply-Demand Balance

Consumption of coarse residue by Montana users plus historic levels of out-of-state use of Montana coarse residue should exceed 1,100 cunits. Demand in and out of Montana should be sufficient to utilize virtually all of the coarse residue available, even in years of relatively high lumber and plywood production.

A new large facility requiring coarse residue would have to compete directly with existing users. The supply-demand balance, therefore, focuses on fine residue (sawdust, sander dust, and planer shavings) and bark.

The users should be aware that the program will allow them to make assumptions that would indicate large volumes of unutilized coarse residue; however, at present these assumptions would be very unrealistic.

Menu item (K) provides a summary of mill residue supply and demand in Montana for fine residue and bark. In table 4's total column, the first number is the volume of mill residue generated from lumber and plywood production, which is equal to the totals in table 2 for sawdust, sander dust, planer shavings, and bark. The third number is the volume generated adjusted for internal hog fuel use. It represents the total supply available for product or external hog fuel uses, and is equal to the corresponding totals in table 3.

The fourth number in this column is the aggregated market demand for these four mill residue types; it is the sum of product use and external hog fuel use. The level of this aggregated demand, of course, depends on the various demand assumptions defined in menu items (E) and (F), which are discussed in section 3.4.

By consolidating mill residue supply and market demand conditions, the last number shows the balance of fine residue and bark in Montana. A positive balance means supply exceeds demand, leaving a surplus. A negative balance, as in the case of table 4, indicates a deficit as a result of supply falling short of demand.

Table 4
Supply-Demand Balance, Sawdust, Sander Dust, Planer Shavings, and Bark
Montana, 1986
(In Thousands of Cunits)

		Total[1]
Fine residue and bark generated		
From lumber production	1,031	
From plywood production	93	1,125
Less: Internal hog fuel use		267
		858
Demand for fine residue and bark		
Product use	414	
External hog fuel use	240	654
Balance		204

[1] Detail for the rows and columns may not add to the total due to rounding in the computer program.

Table 5 displays supply, shipments, and unutilized volumes by type of mill residue by county or county group. It begins with the volume of mill residue generated, adjusted for internal hog fuel use. The second row shows the volume of mill residue shipments, which is derived from a simulation algorithm which takes into account (1) the historic mix of mill residue used as inputs for products and hog fuel, (2) the volume and the component of mill residue generated, and (3) the location of the mill residue supply.

The third row indicates unutilized mill residue volumes by type. It is the difference between the volume of mill residue after internal hog fuel use and the simulated volume of shipments to other users. Finally, the remainder of the table provides a breakdown of mill residue inventory by type and by county or county group in Montana. Its derivation is, of course, related to the algorithm used in the simulation of mill residue shipments. The program assumes that mill residue users will acquire the material in increments based exclusively on haul distance. Although this is generally the purchasing strategy, it is not followed absolutely. Table 5 should be used to identify large concentrations of mill residue but not necessarily to exclude potential sources of supply.

Note: a zero in a given area does not mean all residue in that county or group of counties is committed to use. It means that if residue were selected strictly on the basis of proximity to the facilities using residues, then all residue in the areas showing zero would be utilized.

Table 5
Supply-Demand Balance, by Type of Mill Residue
Selected Montana Counties and County Groups, 1986
(In Thousands of Cunits)

	Sawdust	Sander Dust	Planer Shavings	Bark	Total[3]
Fine mill residue and bark generated (after internal use)[1]	359	0	328	170	858
Shipments[2]	268	0	291	91	651
Unutilized residue[1]	91	0	36	78	206
Beaverhead Area	49	0	14	19	83
Broadwater Area	22	0	20	8	51
Carbon Area	1	0	1	0	3
Flathead County	9	0	0	27	36
Granite Area	0	0	0	0	0
Lake Area	0	0	0	0	0
Lincoln County	9	0	0	22	31
Missoula County	0	0	0	0	0

[1] Statewide total production.

[2] Statewide total shipments to mills in Montana and in other states.

[3] Detail for the rows and columns may not add to the total due to rounding in the computer program.

Table 4

Estimated Annual Volume of Limb and Topwood Available Whole Tree Hauling of Sawtimber Montana

	REGION				
	Northwest	Southwest	North Central	South Central	Total
Estimated annual volume of sawtimber processed (MMBF)	620	320	96	110	1,146
Oven dry tons of topwood per MMBF	925	925	925	925	925
Thousand oven dry tons of limb and topwood potentially available	574	296	89	102	1,061
Limb and topwood after breakage and diameter adjustment (thousands of oven dry tons)	276	142	48	55	521

Other Components of Forest Residue

Other components of forest residue include material from timber stand improvement projects, older slash, dead and cull material on unlogged sites, especially insect-killed timber, as well as material from noncommercial timberlands.

Timber Stand Improvement. Residue from timber stand improvement projects in the study area has two sources: precommercial thinning operations and conversion of stagnant stands of lodgepole pine to properly stocked stands of seedlings. In both cases, the trees available are small (less than 7 inches d.b.h.) and expensive to recover. Although numerous regions in Montana have large acreages suitable for thinning or stand conversion, only northwestern Montana has substantial acreage available for stand conversion. Based on discussion with land managers in the area, mechanized felling and bunching would not be allowed on many of the sites scheduled for thinning, to avoid damage to trees allowed to remain standing. Because hand felling and bunching to recover large volumes would be extremely expensive (over $75 per hundered cubic feet of solid wood, chipped and delivered), thinning residue was not viewed as a viable large volume source of wood fiber for energy use.

Material from stand conversion would be cheaper, but still expensive. At present there are about 75,000 acres of stagnant lodgepole pine stands in the regulated timber on the Kootenai National Forest (Park 1984). Other ownerships in the area should offer 20,000 to 30,000 additional acres (Montana Department of State Lands 1982). Adjacent National Forests would increase the acres available. Estimates indicate that there are more than 30 oven dry tons of recoverable forest residues per acre in this area (Koch 1988). Total volumes potentially available from stand conversion operations

1988). Total volumes potentially available from stand conversion operations would certainly exceed 2 million oven dry tons.

Koch has estimated the cost of recovering this material to be $47.50 per oven dry ton (1988). Not all of this material is available, but Koch suggested that 110,000 oven dry tons of stemwood would be available each year for twenty years for industrial or energy development. Heavy harvesting of lodgepole pine sawtimber in northwestern Montana could reduce this volume by limiting the amount of timber available for further harvest.

Older Logging Slash. Besides wood fiber from recently completed logging operations, wood residue is available in the form of slash from logging operations completed in the last 10 to 15 years. In the mid-1970s, large volumes of slash were generated and left behind in the Northern Region (USFS 1974). Since the mid-1970s, however, slash treatment has generally kept pace with harvesting operations, so large volumes of untreated slash are not available from more recent operations. The inventory of logged-over lands completed in 1984 also indicates greatly improved slash disposal.

Slash from previous years' logging operations would be generally more expensive to recover than from recently logged lands. Old slash areas therefore could not be expected to contribute a significant amount of wood fiber to a potential user. .

Other Dead and Cull Timber. There is an enormous quantity of dead and cull green timber in the Northern Rocky Mountains, much of it in stands unlikely to be logged for sawtimber. A large portion of this material is far from roads, scattered, and expensive to recover. The unit cost of a logging operation depends on the volume per acre to be removed, generally decreasing as more volume per acre is removed. The selective logging of dead and cull green material would consequently be more expensive than the harvesting of the same material in conjunction with a sawtimber harvesting operation in which much larger volumes per acre were harvested. Some selective logging of dead timber does occur in the Northern Rocky Mountains, especially for firewood and high value products such as house logs.

An infestation of mountain pine beetle in portions of the state has reached epidemic proportions. It is anticipated that all lodgepole pine stands over 80 years old and 6 inches in diameter on the Kootenai National Forest will be infested by the mountain pine beetle within the next 10 years (USDA Forest Service, 1982). This represents a volume of just under 3 billion board feet. The Kootenai National Forest has undertaken a large salvage program aimed at recovering the dead lodgepole pine for lumber. However, levels will be much lower than the amount of wood available because of the limited capability of the wood products industry to process lodgepole pine, and because of constraints imposed by accessibility and other resource considerations. Given present recovery rates, only about 1/3 of the 3 billion board feet of dead lodgepole pine will be recovered by 1995. At that time much of the pine will have been dead for more than 10 years, so its potential for lumber will be greatly reduced. Beetle-killed pine could then become a major source of wood fiber for fuel in the period after 1995.

In the summer of 1988, massive fires burned tens of thousands of acres in Montana. At the time this report was completed, it was not possible to determine the impact of the fires on the availability of timber in general or forest residue in particular. It is almost certain, however, that all of the fire-killed timber will not be recovered for products. As the fire-killed timber deteriorates and loses its product potential, the volume of forest residue available for fuel in the future will increase.

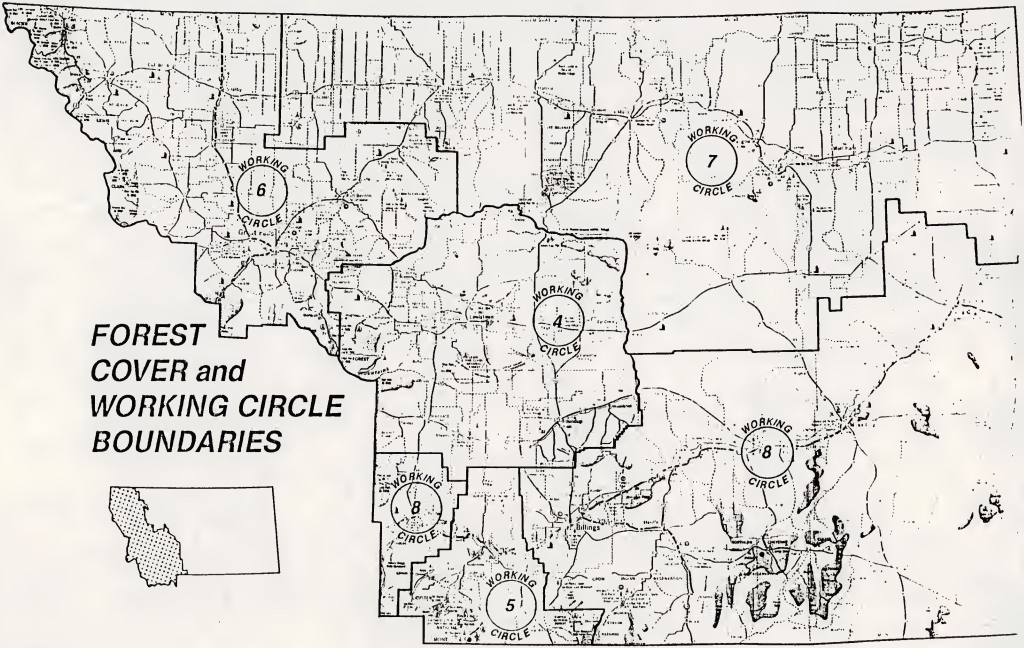
Wood Availability for Energy
Eastern Montana

The most recent forest inventory for eastern Montana was performed in 1977, 1979, and 1980. The results of that inventory were released in July, 1984, by the Montana Department of State Lands, the USDA Intermountain Research Station and Region 1, US Forest Service.

Forest Inventory Working Circles 4, 5, 6, 7 and 8 cover 37 counties, the eastern two-thirds of the state of Montana (see Figure 2). The area, 97,539 square miles (62,424,981 acres), is larger than all of New England plus the states of West Virginia, Delaware, and half of New Jersey; it is an area larger than the state of Oregon (97,073 square miles) about the size of Wyoming (97,809 square miles).

Almost 69 percent (62.4 million acres) is privatly owned. The balance is owned or managed as follows: 3.8 percent, National Forests; 10.8 percent, Bureau of Land Management; 7.4 percent, Bureau of Indian Affairs; 2.7 percent, National Park Service and miscellaneous federal; 6.3 percent, state of Montana; and 0.2 percent, county and municipal.

Thirty-five of the thirty-seven counties have commercial timberlands. The amount of commercial timberland in each county varies from none to 16.6 percent of the total area of the county. Commercial timberland makes up only 1.9 percent of the total land area. Public agencies manage 14.3 percent of the commercial timberland with private ownership of the other 85.6 percent (see Appendix Tables 2A and 3A).



FOREST COVER and WORKING CIRCLE BOUNDARIES

Because the amount of commercial timberland is small and the timberlands are scattered over such a large geographical area, sampling intensities in the inventory were low and sampling accuracies were poor. Appendix Table 1A illustrates the sampling accuracies for both commercial timberland acreages and the volume, growth, and mortality of the growing stock on the commercial timberlands. The report dealt only with the timber volumes found on commercial timberlands; noncommercial timberlands do not contain the timber volumes or the timber growing capabilities to provide commercial quantities of timber.

The species composition of the commercial timberlands varies from 100 percent hardwoods in one county to 99.6 percent softwoods in another; however, 87.3 percent of all the commercial timber is softwoods and 12.7 percent hardwoods.

The breakdown of species volumes, by ownership class, parallels the commercial timberland ownership; 12.3 percent of the growing volume is on public land and 87.7 percent is on private land (see Appendix tables 4 and 5).

Current Use

The established forest industry in the area consists of relatively small sawmills and post and pole operations (see Appendix Table 6). Logs are also exported from the area to sawmills in South Dakota, Wyoming, and western Montana.

Commercial timber harvest from private lands has fluctuated wildly in the past; during the fifteen-year period from 1968 to 1982, the annual harvest ranged from less than 1.1 million board feet to more than 36.2 million board feet, with an annual average of just over 14.9 million board feet or approximately 4 million cubic feet of wood.

Wood is used in eastern Montana for energy, mostly for home heating, and this use is expected to continue. Approximately 52 percent of the households in rural electric cooperatives in eastern portions of the state use wood either as their primary or secondary source of heat (Montana Department of Natural Resources, 1987). This represents about 63,000 cords per year consumed for heating east of the continential divide.

Potential for Development of Wood Energy

Estimates of volumes of forest residue, as defined earlier in this report, are not available for eastern Montana. Volumes of forest residue available annually in the eastern portions of Montana are certainly smaller than in western Montana, both because of the much smaller acreages of timberland and because the drier forest sites (typical of eastern Montana) generally produce lower volumes of residue per acre. In fact, it is virtually certain that no large wood-fired industrial or energy facility could be successfully developed in eastern Montana.

A 25 megawatt, stand-alone, wood-fired electrical power generation plant would require approximately 180,000 tons of bone-dry wood annually. This is a relatively small plant; below this size there appear to be large losses in operating efficiencies (Keegan et al. 1987).

Appendix tables 8 and 9 show net volume, bone-dry weight, annual growth, mortality and net growth volume of the growing stock on the commercial timberlands in the area. The gross annual growth of all species has been calculated to produce the equivalent of 397,600 bone-dry tons of wood. A single 25 megawatt power plant would require 45 percent of the annual growth on commercial forest lands in eastern Montana.

Wood will continue to meet the individual home heating needs and the needs of the established forest industry in eastern Montana, but the cost of collecting and transporting large volumes of wood over long distances appears to make any large-scale energy generating facility uneconomical. This is especially true in light of the low-cost coal available in the same area.

Selected Definitions

Commercial Timberland	Forest land used for producing or capable of producing commercial crops of industrial wood and not withdrawn from such use. (Note: Areas qualifying as productive forest land are capable of producing in excess of 20 cubic feet per acre per year of industrial wood under management. Currently inaccessible and inoperable areas are included, except where the areas involved are small and unlikely to become suitable for production of industrial wood in the forseeable future.)
Cull	A tree or portions of a tree that is unusable for industrial wood products because of rot, deformity, or other defect.
Forest Land	Land at least 16.7 percent stocked by forest trees, or formerly having such tree cover, and not currently developed for nonforest use.
Growing Stock Volume	Net volume in cubic feet of live sawtimber trees and live poletimber trees (all trees 5.0 inches d.b.h. and larger) from stump to a minimum 4.0 inch top (of the central stem) outside bark. Net volume equals gross volume less deduction for rot and missing bole sections.
Hardwoods	Dicotyledonous trees, usually broad-leaved and deciduous.
Noncommercial Forest Land	Forest land incapable of producing 20 cubic feet per acre of industrial wood under management because of adverse site conditions. Includes only nonreserved forest land.
Nonforest Land	Land that has never supported forests and lands formerly forested where use for timber management is precluded by development for other purposes.
Other Forest Land	See noncommercial forest land.
Salvable Dead	Standing and down dead trees 5.0 inches d.b.h. and larger and more than 50 percent sound on a cubic foot basis.
Softwoods	Coniferous trees, usually evergreen, having needle or scale-like leaves.

Appendix

All data contained in tables 1, 2, 3, 4, 7, and 8, unless otherwise noted, came from the following publication:

"Timber Resources of Eastern Montana"
Working Circles 4, 5, 6, 7, and 8

by

Montana Department
of State Lands
Division of Forestry
and
Forest Survey
Intermountain Forest and Range Experiment Station
Region 1, USDA Forest Service

or from the statistical data developed for the above named publication.

Appendix Table 1

Data Reliability

The sampling errors in this table are calculated for one standard error - 67% confidence level (in 2 out of 3 times the actual value will be within the confidence interval). Individual cells within tables should be used with caution. Some of the data presented are based on small sample sizes and, as a result, have high sampling errors.

Commercial Timberland Area and Sampling Error Percentages

Working Circle	*Softwood Types*		*Hardwood Types*		*All Types*	
	Acres	Error	Acres	Error	Acres	Error
WC-4	429,037	± 5.0%	16,992	±38.0%	446,029	± 4.8%
WC-5	65,892	± 8.0%	18,913	±18.6%	84,806	± 5.9%
WC-6	123,805	± 6.1%	15,979	±26.9%	139,784	± 5.4%
WC-7 & 8	394,743	± 9.2%	95,222	±14.1%	489,964	± 7.9%

Net Volume, Net Annual Growth & Annual Mortality of Growing Stock on Commercial Timberlands Sampling Error Percentages (Thousand Cubic Feet)

Working Circle	*Softwood Species*		*Hardwood Species*		*All Species*	
	Volume	Error	Volume	Error	Volume	Error
WC-4						
Volume	406,902	± 8.2%	25,124	± 38.7%	432,026	± 7.8%
Net growth	10,824	± 9.1%	757	± 42.4%	11,582	± 9.0%
Mortality	1,504	±27.8%	71	± 63.3%	1,575	±26.3%
WC-5						
Volume	52,251	±14.7%	20,178	± 23.4%	72,428	±11.1%
Net growth	874	±20.7%	605	± 33.8%	1,479	±17.2%
Mortality	323	±24.8%	78	± 35.4%	401	±20.8%
WC-6						
Volume	150,103	±13.6%	16,574	± 29.7%	166,678	±12.6%
Net growth	3,132	±15.9%	316	± 25.3%	3,448	±14.7%
Mortality	166	±52.9%	20	±100.0%	186	±48.2%
WC-7 & 8						
Volume	307,309	±10.6%	106,078	± 19.1%	413,387	± 9.4%
Net growth	8,198	±16.3%	1,463	± 55.6%	9,661	±16.2%
Mortality	1,182	±35.9%	926	± 53.3%	2,109	±31.2%

Appendix Table 2

Timberland Resources of Eastern Montana
Acres
Working Circles 4, 5, 6, 7 and 8

Working Circle & Owner Class	Total Land Area	Commercial Timberland	%	Other Timberland	%	Total Timberland	Total Timberland As % of Total Area
WC-4							
Public*	1,968,512	39,900	2.0%	14,500	0.7%	54,400	2.8%
%	25.0%	8.9%		9.2%		9.0%	
Private	5,919,175	406,100	6.9%	142,900	2.4%	548,900	9.3%
%	75.0%	91.1%		90.8%		91.0%	
Total	7,887,687	446,000	5.7%	157,300	2.0%	603,300	7.6%
%	100.0%	100.0%		100.0%		100.0%	
WC-5							
Public*	847,156	8,500	1.0%	1,800	0.2%	10,300	1.2%
%	34.3%	10.0%		6.7%		9.2%	
Private	1,623,436	76,300	4.7%	25,200	1.6%	101,400	6.2%
%	65.7%	90.0%		93.3%		90.8%	
Total	2,470,590	84,800	3.4%	27,000	1.1%	111,800	4.5%
%	100.0%	100.0%		100.0%		100.0%	
WC-6							
Public*	2,793,760	10,000	0.4%	4,200	0.2%	14,200	0.5%
%	28.1%	7.1%		7.0%		7.1%	
Private	7,137,988	129,800	1.8%	55,500	0.8%	185,300	2.6%
%	71.9%	92.9%		93.1%		92.9%	
Total	9,931,748	139,800	1.4%	59,600	0.6%	199,400	2.0%
%	100.0%	100.0%		100.0%		100.0%	

NOTE: Totals may not add due to rounding.

Appendix Table 2 (continued)

Timberland Resources of Eastern Montana
Acres
Working Circles 4, 5, 6, 7 and 8

Working Circle & Owner Class	Total Land Area	Commercial Timberland	%	Other Timberland	%	Total Timberland	Total Timberland As % of Total Area
WC-7							
Public*	7,585,498	29,000	0.4%	44,000	0.6%	73,100	1.0%
%	35.6%	32.3%		43.1%		38.1%	
Private	13,733,652	60,900	0.4%	58,100	0.4%	119,000	0.9%
%	64.4%	67.7%		56.9%		61.9%	
Total	21,319,150	89,900	0.4%	102,200	0.5%	192,100	0.9%
%	100.0%	100.0%		100.0%		100.0%	
WC-8							
Public*	6,266,422	67,600	1.1%	69,700	1.1%	137,300	2.2%
%	30.1%	16.9%		19.2%		18.0%	
Private	14,551,382	332,400	2.3%	293,000	2.0%	625,300	4.3%
%	69.9%	83.1%		80.8%		82.0%	
Total	20,817,804	400,000	1.9%	362,600	1.7%	762,700	3.7%
%	100.0%	100.0%		100.0%		100.0%	
Eastern Montana Total - WC-4,5,6,7,8							
Public*	19,461,348	155,100	0.8%	134,200	0.7%	289,400	1.5%
%	31.2%	13.4%		18.9%		15.5%	
Private	42,965,633	1,005,400	2.3%	574,600	1.3%	1,580,000	3.7%
%	68.8%	86.6%		81.1%		84.5%	
Total	62,424,981	1,160,600	1.9%	708,700	1.1%	1,869,300	3.0%
%	100.0%	100.0%		100.0%		100.0%	

*Public Ownership Class includes: USDA Forest Service, USDI Bureau of Land Management, USDI Bureau of Indian Affairs, USDI National Park Service, miscellaneous Federal, Montana Department of State Lands, other state, county and municipal.

NOTE: Totals may not add due to rounding.

Appendix Table 3

Commercial Timberland of Eastern Montana By Counties
(Thousands of Acres)

			Commercial Forest Land by - - - *Ownership** - - - -				Commercial Forest Land by - - - - - *Timber Type* - - - -			
County	Working Circle	Total Land Area^a	Public	Private	Total	% of County Area	Soft-Wood	%	Hard-Wood	%
Big Horn	8	3,188.8	3.6	52.5	56.1	1.8%	49.5	88.2%	6.6	11.8%
Blaine	7	2,724.7	2.1	10.8	12.9	0.5%	8.1	63.3	4.7	36.7
Carbon	5	1,315.8	5.0	34.6	39.7	3.0	28.8	72.7	10.8	27.3
Carter	8	2,139.2	3.2	14.1	17.3	0.8	14.6	84.9	2.6	15.1
Cascade	6	1,727.2	5.3	85.7	91.0	5.3	84.1	92.4	6.9	7.6
Choteau	6	2,552.0	1.3	20.3	21.6	0.8	18.6	86.1	3.0	13.9
Custer	8	2,416.6	9.4	28.7	38.1	1.6	31.4	82.2	6.8	17.8
Daniels	7	913.2	---	---	---	---	---	---	---	---
Dawson	8	1,519.4	1.4	3.8	5.2	0.3	1.4	26.9	3.8	73.1
Fallon	8	1,038.6	0.2	1.4	1.5	0.1	0.5	33.3	0.9	66.7
Fergus	4	2,777.7	13.1	156.4	169.5	6.1	157.0	92.6	12.5	7.4
Garfield	7	2,874.3	19.2	15.1	34.3	1.2	30.0	87.5	4.3	12.5
Glacier	6	1,916.5	---	6.2	6.2	0.3	5.2	83.9	1.0	16.1
Golden Valley	4	749.9	1.7	24.5	26.2	3.5	25.4	96.9	0.8	3.1
Hill	7	1,854.3	1.2	4.9	6.1	0.3	3.9	63.9	2.2	36.1
Judith Basin	4	1,197.3	1.2	15.4	16.6	1.4	15.7	94.6	0.9	5.4
Liberty	7	912.9	0.8	1.8	2.7	0.3	1.1	42.3	1.5	57.7
McCone	7	1,680.8	---	2.4	2.4	0.1	---	---	2.4	100.0
Musselshell	4	1,197.2	18.7	180.0	198.7	16.6	198.0	99.6	0.7	0.4
Petroleum	4	1,057.3	4.3	15.8	20.1	1.9	19.8	98.5	0.3	1.5
Phillips	7	3,283.4	3.3	6.5	9.8	0.3	5.7	58.2	4.1	41.8
Pondera	6	1,044.3	1.6	3.7	5.2	0.5	3.8	73.1	1.4	26.9
Powder River	8	2,104.1	16.7	38.6	55.3	2.6	44.9	81.2	10.4	18.8
Prairie	8	1,108.8	0.9	0.6	1.5	0.1	1.1	73.3	0.4	26.7

NOTE: Totals may not add due to rounding.

Appendix Table 3 (continued)

Commercial Timberland of Eastern Montana By Counties
(Thousands of Acres)

			Commercial Forest Land by - - - *Ownership** - - - -				Commercial Forest Land by - - - - - *Timber Type* - - - -			
County	Working Circle	Total Land Area[a]	Public	Private	Total	% of County Area	Soft-Wood	%	Hard-Wood	%
Richland	7	1,332.1	0.6	8.7	9.3	0.7	0.1	1.1	9.2	98.9
Roosevelt	7	1,508.7	0.4	3.7	4.1	0.3	---	---	4.1	100.0
Rosebud	8	3,212.0	11.7	64.2	75.9	2.4	69.4	91.8	6.4	8.4
Sheridan	7	1,075.6	---	---	---	---	---	---	---	---
Stillwater	5	1,147.5	3.5	41.7	45.1	3.9	37.1	82.1	8.1	17.9
Sweetgrass	8	1,218.2	8.0	58.7	66.7	5.5	61.3	91.9	5.4	8.1
Teton	6	1,456.2	1.9	12.4	14.2	1.0	11.1	78.2	3.1	21.8
Toole	6	1,235.7	---	1.5	1.5	0.1	1.0	62.5	0.6	37.5
Treasure	8	624.1	2.4	21.5	23.9	3.8	19.7	82.9	4.3	17.9
Valley	7	3,159.1	1.3	7.1	8.4	0.3	0.5	6.0	7.9	94.0
Wheatland	4	908.4	1.0	13.9	14.9	1.6	13.1	87.3	1.9	12.7
Wibaux	8	568.6	0.5	0.7	1.2	0.2	0.8	66.7	0.4	33.3
Yellowstone	8	1,679.4	9.7	47.5	57.3	3.4	50.7	88.5	6.6	11.5
Totals		62,419.7	155.0	1,005.4	1,160.5	1.9%	1,013.4	87.3%	147.1	12.7%

*Public Ownership Class includes: USDA Forest Service, USDI Bureau of Land Management, USDI Bureau of Indian Affairs, USDI National Park Service, miscellaneous Federal, Montana Department of State Lands, other state, county and municipal.

[a] From Bureau of Census 16-Oct. 1981

NOTE: Totals may not add due to rounding.

Appendix Table 4

Timber Resources of Eastern Montana
Volume of Timber on Commercial Timberlands
(Thousand Cubic Feet)

Working Circle	Softwoods	%	Hardwoods	%	Total	% Public*	% Private
WC-4							
All growing stock	460,902	94.8%	25,124	5.2%	486,026	8.5%	91.5%
Sound cull	10,454	92.5	851	7.5	11,305	8.8	91.2
Rotten cull	702	72.7	263	27.3	965	8.1	91.9
Salvable dead	18,393	91.6	1,692	8.4	20,085	7.9	92.1
Total	490,451	94.6%	27,930	5.4%	518,381	8.4%	91.6%
% of Column Total	47.8%		15.6%		43.0%		
WC-5							
All growing stock	52,251	72.1%	20,177	27.9%	72,428	10.6%	89.4%
Sound cull	819	76.9	246	23.1	1,065	9.5	90.5
Rotten cull	29	48.3	31	51.7	60	8.3	91.7
Salvable dead	1,934	69.9	831	30.1	2,765	69.9	30.1
Total	55,033	72.1%	21,285	27.9%	76,318	10.6%	89.4%
% of Column Total	5.4%		11.9%		6.3%		
WC-6							
All growing stock	150,103	90.1%	16,575	9.9%	166,678	6.9%	93.1%
Sound cull	652	79.8	164	20.1	817	7.7	92.3
Rotten cull	124	58.2	89	41.8	213	7.0	93.0
Salvable dead	5,966	84.3	1,109	15.7	7,075	6.9	93.1
Total	156,845	89.7%	17,937	10.3%	174,782	6.9%	93.1%
% of Column Total	15.3%		10.0%		14.5%		

NOTE: Totals may not add due to rounding.

Appendix Table 4 (continued)

Timber Resources of Eastern Montana
Volume of Timber on Commercial Timberlands
(Thousand Cubic Feet)

Working Circle	Softwoods	%	Hardwoods	%	Total	% Public*	% Private
WC-7 & 8							
All growing stock	307,309	74.3%	106,078	25.7%	413,387	19.3%	80.7%
Sound cull	7,638	100.0	-0-	---	7,638	21.2	78.8
Rotten cull	720	49.7	729	50.3	1,449	17.1	82.9
Salvable dead	7,542	57.5	5,571	42.5	13,113	14.0	86.0
Total	323,209	74.2%	112,378	25.8%	435,586	19.2%	80.8%
% of Column Total	31.5%		62.6%		36.1%		
WC-4,5,6,7 & 8							
All growing stock	970,565	85.2%	167,954	14.8%	1,138,519	12.3%	87.7%
Sound cull	19,563	93.9	1,261	6.1	20,825	13.3	86.7
Rotten cull	1,575	58.6	1,112	41.4	2,687	12.9	87.1
Salvable dead	33,835	78.6	9,203	21.4	43,038	9.8	91.2
Total	1,025,538	85.1%	179,530	14.9%	1,205,069	12.2%	87.8%
% of Column Total	100.0%		100.0%		100.0%		

*Public Ownership Class includes: USDA Forest Service, USDI Bureau of Land Management, USDI Bureau of Indian Affairs, USDI National Park Service, miscellaneous Federal, Montana Department of State Lands, other state, county and municipal.

NOTE: Totals may not add due to rounding.

Appendix Table 5

Net Volume Growing Stock on Commercial Timberland of Eastern Montana by Counties (Thousand Cubic Feet)

County	Working Circle	Public*	%	Private	%	Total	Soft-Wood %	Hard-Wood %
Big Horn	8	2,213	5.8	35,684	94.2%	37,897	81.0%	19.0%
Blaine	7	2,037	16.3	10,465	83.7	12,502	57.3	42.7
Carbon	5	4,703	13.5	30,094	86.5	34,797	67.7	32.3
Carter	8	2,253	17.0	10,970	83.0	13,222	78.1	21.9
Cascade	6	6,250	5.8	101,207	94.2	107,457	93.6	6.4
Choteau	6	1,225	4.5	25,853	95.5	27,078	88.7	11.3
Custer	8	6,955	23.9	22,169	76.1	29,125	74.5	25.5
Daniels	7	---	---	---	---	---	---	---
Dawson	8	1,319	25.5	3,851	74.5	5,170	19.0	81.0
Fallon	8	151	10.6	1,277	89.4	1,428	21.8	78.2
Fergus	4	19,247	7.7	230,350	92.3	249,597	92.6	7.4
Garfield	7	18,420	55.5	14,761	44.5	33,181	83.4	16.8
Glacier	6	19	0.3	7,723	99.7	7,743	86.2	13.8
Golden Valley	4	2,276	6.3	33,796	93.7	36,072	96.6	3.4
Hill	7	1,317	20.6	5,076	79.4	6,393	60.7	39.3
Judith Basin	4	2,032	8.1	23,034	91.9	25,066	94.2	5.8
Liberty	7	987	33.0	2,007	67.0	2,994	42.6	57.4
McCone	7	---	---	2,617	100.0	2,617	---	100.0
Musselshell	4	13,123	9.4	126,831	90.6	139,954	99.4	0.6
Petroleum	4	2,917	21.8	10,462	78.2	13,379	97.1	2.9
Phillips	7	3,248	32.5	6,743	67.5	9,991	53.3	46.7
Pondera	6	1,856	29.2	4,505	70.8	6,361	76.3	23.7
Powder River	8	11,898	28.4	29,956	71.6	41,854	72.8	27.2
Prairie	8	626	54.7	519	45.3	1,145	60.7	39.3

NOTE: Totals may not add due to rounding.

Appendix Table 5 (continued)

Net Volume Growing Stock on Commercial Timberland of Eastern Montana by Counties (Thousand Cubic Feet)

County	Working Circle	Public*	%	Private	%	Total	Soft-Wood %	Hard-Wood %
Richland	7	705	7.0	9,435	93.0	10,140	0.3	99.7
Roosevelt	7	467	10.3	4,049	89.7	4,516	---	100.0
Rosebud	8	7,669	15.5	41,969	84.5	49,637	85.8	14.2
Sheridan	7	---	---	---	---	---	---	---
Stillwater	5	2,951	7.8	34,681	92.2	37,632	76.3	23.7
Sweetgrass	8	9,356	10.8	76,903	89.2	86,259	92.7	7.3
Teton	6	2,121	13.3	13,773	86.7	15,894	78.6	21.4
Toole	6	---	---	2,146	100.0	2,146	69.8	30.2
Treasure	8	1,531	9.4	14,751	90.6	16,283	71.3	28.7
Valley	7	1,324	14.5	7,783	85.5	9,107	4.2	95.8
Wheatland	4	1,524	6.9	20,435	93.1	21,959	87.7	12.3
Wibaux	8	399	43.6	516	56.4	915	51.1	48.9
Yellowstone	8	6,964	17.9	32,048	82.1	39,012	81.4	18.6
Total	4,5,6,7 & 8	140,080	12.3%	998,440	87.7%	1,138,519	85.2%	14.8%

*Public Ownership Class includes: USDA Forest Service, USDI Bureau of Land Management, USDI Bureau of Indian Affairs, USDI National Park Service, miscellaneous Federal, Montana Department of State Lands, other state, county and municipal.

NOTE: Totals may not add due to rounding.

Appendix Table 6

Forest Industry - Eastern Montana
By County

		- - - - *Sawmills*[a] - - - - *Million Bd. Ft. Production*					
County	Working Circle	< 1MM	1-5	5-10	10-15	Post & Poles[a]	Logging Operators[b]
Big Horn	8						1
Carbon	5						1
Cascade	6		1				1
Choteau	6					1	
Fergus	4	4		1		2	14
Judith Basin	4		1				
Musselshell	4		2				4
Rosebud	8		1				
Stillwater	5		1				1
Sweetgrass	8	1					
Wheatland	4				1		1
Yellowstone	8					1	
Totals		5	6	1	1	4	23

Reported Sawmill Production: 33.4MM/year

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[a] 1987 Directory of Montana's Forest Products Industry, Montana Department of State Lands, Division of Forestry.

[b] 1987 Directory of Montana's Forest Industry Contractors, Montana Department of State Lands, Division of Forestry.

Appendix Table 7

Bone-Dry Weight, Pounds Per Cubic Foot By Species

Species	Lbs. Per Cu. Ft. @ 15% M.C. [a]	Adj. Factor Per 1% M.C. Change[a]	Amount Weight Change to 0% M.C.	Bone-Dry Weight Lbs. Per Cu. Ft.
Ponderosa Pine	28.6	.162	2.4	26.2
Douglas Fir (Rocky Mtn.)	30.5	.179	2.7	27.8
Lodgepole Pine	29.2	.142	2.1	27.1
Whitebark, Limberpine	26.7	.129	1.9	24.8
Englemann Spruce	24.1	.129	1.9	22.2
Sub-Alpine Fir	22.5	.167	2.5	20.0
Juniper	36.7	.179	2.7	34.0
Cottonwood	24.5	.104	1.6	22.9
Aspen	27.0	.129	1.9	25.1
Other hardwoods (approx.)	30.0	.150	2.3	27.7

[a] USDA Wood Handbook, Handbook No. 72 (1955)

Appendix Table 8

Net Volume and Weight of Growing Stock on Commercial Timberlands, All Ownerships Working Circles 4, 5, 6, 7 and 8 (Thousand Cubic Feet)

Working Circle & Species	Volume M Cu. Ft.	% of Total	Bone Dry Lbs./Cu. Ft.[a]	Thousand Tons
WC-4				
PP	359,147	73.9	26.2	4,704.8
DF	73,974	15.2	27.8	1,028.2
LPP	18,090	3.7	27.1	245.1
WBP-LP	1,624	0.3	24.8	20.1
ES	7,813	1.6	22.2	86.7
AF	254	0.1	20.0	2.5
Total	460,902	94.8	26.4	6,087.4
Cottonwood	4,630	1.0	22.9	53.0
Aspen	20,494	4.2	25.1	257.2
Total	25,124	5.2	24.7	310.2
Total - All	486,026	100.0	26.3	6,397.6
WC-5				
PP	32,325	44.6	26.2	423.5
DF	14,464	20.0	27.8	201.0
LPP	3,621	5.0	27.1	49.1
WBP-LP	1,565	2.2	24.8	19.4
ES	275	0.4	22.2	3.1
AF	---	---	---	---
Total	52,251	72.1	26.6	696.1
Cottonwood	14,476	20.0	22.9	165.8
Aspen	5,702	7.9	25.1	71.6
Total	20,178	27.9	23.5	237.4
Total - All	72,428	100.0	25.8	933.5

NOTE: Totals may not add due to rounding.

Appendix Table 8 (continued)

Net Volume and Weight of Growing Stock
on Commercial Timberlands, All Ownerships
Working Circles 4, 5, 6, 7 and 8
(Thousand Cubic Feet)

Working Circle & Species	Volume M Cu. Ft.	% of Total	Bone Dry Lbs./Cu. Ft.[a]	Thousand Tons
WC-6				
PP	32,123	19.3	26.2	420.8
DF	69,427	41.7	27.8	965.0
LPP	42,787	25.7	27.1	579.8
WBP-LP	4,884	2.9	24.8	60.6
ES	748	0.4	22.2	8.3
AF	134	0.1	20.0	1.3
Total	150,103	90.1	27.1	2,035.8
Cottonwood	12,081	7.2	22.9	138.3
Aspen	2,404	1.4	25.1	30.2
Other hardwoods	2,090	1.3	27.7	28.9
Total	16,574	9.9	23.8	197.4
Total - All	166,678	100.0	26.8	2,233.2
WC-7				
PP	27,953	30.6	26.2	366.2
DF	6,378	7.0	27.8	88.7
LPP	11,377	12.4	27.1	154.2
WBP-LP	---	---	---	---
ES	---	---	---	---
AF	---	---	---	---
Total	45,708	50.0	26.7	609.1
Cottonwood	39,036	42.7	22.9	447.0
Aspen	6,696	7.3	25.1	84.0
Total	45,733	50.0	23.2	531.0
Total - All	91,441	100.0	24.9	1,140.1

NOTE: Totals may not add due to rounding.

Appendix Table 8 (continued)

Net Volume and Weight of Growing Stock on Commercial Timberlands, All Ownerships Working Circles 4, 5, 6, 7 and 8 (Thousand Cubic Feet)

Working Circle & Species	Volume M Cu. Ft.	% of Total	Bone Dry Lbs./Cu. Ft.[a]	Thousand Tons
WC-8				
PP	206,630	64.2	26.2	2,706.9
DF	41,620	12.9	27.8	578.5
LPP	6,614	2.1	27.1	89.6
WBP-LP	3,731	1.2	24.8	46.3
ES	2,502	0.8	22.2	27.8
AF	506	0.2	20.0	5.1
Total	261,601	81.3	26.4	3,454.2
Cottonwood	60,346	18.7	22.9	691.0
Total	60,346	18.7	22.9	691.0
Total - All	321,946	100.0	25.8	4,145.2

NOTE: Totals may not add due to rounding.

Appendix Table 8 (continued)

Net Volume and Weight of Growing Stock on Commercial Timberlands, All Ownerships Working Circles 4, 5, 6, 7 and 8 (Thousand Cubic Feet)

Species Groups/ Working Circles	Volume M Cu. Ft.	% of Total	Bone Dry Lbs./Cu. Ft.[a]	Thousand Tons
Softwoods				
WC-4	490,902	47.5	26.4	6,087.4
WC-5	52,251	5.4	26.6	696.1
WC-6	150,103	15.5	27.1	2,035.8
WC-7	45,708	4.7	26.7	609.1
WC-8	261,601	26.9	26.4	3,454.2
Total	970,565 85.2%	100.0	26.5	12,882.6
Hardwoods				
WC-4	25,124	15.0	24.7	310.2
WC-5	20,178	12.0	23.5	237.4
WC-6	16,574	9.9	23.8	197.4
WC-7	45,733	27.2	23.2	531.0
WC-8	60,346	35.9	22.9	691.0
Total	167,955 14.8%	100.0	23.4	1,967.0
All species				
WC-4	486,026	42.7	26.3	6,397.6
WC-5	72,428	6.4	25.8	933.5
WC-6	166,678	14.6	26.8	2,233.2
WC-7	91,441	8.0	24.9	1,140.1
WC-8	321,946	28.3	25.8	4,145.2
Total	1,138,519	100.0	26.1	14,849.6

[a] From Table 6

NOTE: Totals may not add due to rounding.

Appendix Table 9

Volume, Annual Gross Growth, Mortality, Net Growth of Growing Stock by Softwood Species Group on Commercial Timberland Working Circles 4, 5, 6, 7 and 8 and by Hardwood Species Group Totaled for the Five Working Circles (Thousand Cubic Feet and Thousand Bone-Dry Tons)

	M Cu. Ft.	% Cu. Ft. Volume	#/Cu. Ft.[a]	M B.D. Tons
Softwood species				
WC-4				
Total volume	460,902	100.0	26.4	6,083.9
Gross growth	12,328	2.7		162.7
Mortality	1,504	0.3		19.9
Net growth	10,824	2.3		142.9
WC-5				
Total volume	52,251	100.0	26.6	694.9
Gross growth	1,197	2.3		15.9
Mortality	323	0.6		4.3
Net growth	874	1.7		11.6
WC-6				
Total volume	150,103	100.0	27.1	2,033.9
Gross growth	3,298	2.2		44.7
Mortality	166	0.1		2.2
Net growth	3,132	2.1		44.4
WC-7 & 8				
Total volume	303,309	100.0	27.0	4,094.7
Gross growth	9,380	3.1		126.6
Mortality	1,182	0.4		16.0
Net growth	8,198	2.7		110.7
Softwood species All working circles				
Total volume	970,565	100.0	26.5	12,860.0
Gross growth	26,203	2.8		347.2
Mortality	3,175	0.3		42.1
Net growth	23,028	2.4		305.1

NOTE: Totals may not add due to rounding.

Appendix Table 9 (continued)

Volume, Annual Gross Growth, Mortality, Net Growth of Growing Stock by Softwood Species Group on Commercial Timberland Working Circles 4, 5, 6, 7 and 8 and by Hardwood Species Group Totaled for the Five Working Circles (Thousand Cubic Feet and Thousand Bone-Dry Tons)

	M Cu. Ft.	% Cu. Ft. Volume	#/Cu. Ft.[a]	M B.D. Tons
Hardwood species All working circles				
Total volume	167,954	100.0	23.4	1,965.1
Gross growth	4,237	2.5		49.6
Mortality	1,096	0.7		12.8
Net growth	3,141	1.9		36.7
All species All working circles				
Total volume	1,138,519	100.0	26.1	14,844.6
Gross growth	30,467	2.7		397.6
Mortality	4,271	0.4		55.7
Net growth	26,169	2.3		341.5

[a] From Table 8

NOTE: Totals may not add due to rounding.

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